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TECHNICAL EVALUATION OF THE ROCKEYE I BOMBLET FUZE MK 258 MOD 0 (U)

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TECHNICAL EVALUATION OF THE ROCKEYE I BOMBLET FUZE MK 258 MOD 0 (U)

Prepared by:
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ABSTRACT: This report contains the results of the comprehensive technical evaluation to which the fuze was subjected. It passed many tests including jumble, 40 foot drop, detonator safety, firing train reliability, transportation vibration, aircraft vibration and temperature cycling tests. Several problems were uncovered. The fuze failed the jolt test, but a modification to the design enabled it to pass this test. It was not operable after the five foot drop test because of damage to the vane and body. Limitations on the use of the weapon may be necessary because the arming time of the fuze in the weapon was found to be longer than expected, and the weapon failed the accidental release test. An operability of approximately 90% was observed on field tests of 596 fuzes.

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 64-97 14 May 1964

Technical Evaluation of the ROCKEYE I Bomblet Fuze Mk 258 Mod 0 (U)

This report describes the laboratory and field tests performed on the Fuze Mk 258 Mod 0 during the course of the technical evaluation conducted by the Naval Ordnance Laboratory, White Oak (NOL(WO)). The work was authorized by BUWEPS (RMMO-22) WEPTASK Assignment RM 37 73001/212-1/W114-00-03 of 16 August 1963. All field tests were conducted at the Naval Weapons Laboratory (NWL), Dahlgren, Virginia, and the Naval Ordnance Test Station (NOTS), China Lake, California. This report summarizes the work performed and makes it available to other interested activities. The information contained in this document does not constitute a recommendation of this fuze by NOL(WO). The contributions of the personnel at NWL and NOTS, who performed the field tests are gratefully acknowledged.

R. E. ODENING
Captain, USN
Commander

R. E. Grantham

R. E. GRANTHAM
By direction

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REFERENCES

(a) BUWEPS (RMMO-22) WEPTASK Assignment RM37 73001/212 1/W114-00 03 of 16 Aug 1964
(b) NOL(WO) ltr KM:WCP:rlf 8010 Ser 0751 of 9 Apr 1962 to BUWEPS (RMMO)

INTRODUCTION

1. Reference (a) authorized the U. S. Naval Ordnance Laboratory, White Oak (NOL(WO)) to develop a ROCKEYE I bomblet fuze. Reference (b) released the fuze to evaluation. Figure 1 is a cutaway view of the fuze.

2. A comprehensive evaluation program was planned and conducted. Figure 2 is a flow chart of this program. Table 1 is a list of the tests performed and the results.

3. The fuze passed various tests including jolt, jumble, 40 foot drop, detonator safety, firing train reliability, transportation vibration, aircraft vibration and temperature cycling tests. The fuze is not sealed and therefore failed the salt spray and temperature and humidity tests. Field tests with 396 fuzes resulted in an operability of 90 percent. The weapon failed the accidental release test, since eight armed, of 30 tested. The jettison safety test resulted in the weapon exploding. However, it is suspected that this failure was due to the bomblets, rather than the fuzes.

4. Earlier designs of the fuze failed the jolt test. Primarily to enable the fuze to pass this test, minor changes in the design were made as the evaluation progressed. These design changes were reflected in the various lots of fuzes used in the evaluation, which were received between November 1962, and November 1963. The chief differences between these lots are as follows:

Lot E - had no double detent assembly. Had small tip on top of firing pin.

Lot F - had double detent assembly. Screws cemented with glyptal. Had improved assembly plate stake. Tip on firing pin removed.

Lot G - like lot F, but had 0.035 inch aluminum extension on firing pin. Assembly screws cemented with EPON 828.

Lot H - like lot G, but had long one piece firing pin. Had deeper nut threads.

Lot I - like lot H, but had washers soldered to under side of assembly screw heads.

5. Lot H was received with out-of-spec timing springs. The inner diameter of the timing spring was smaller than the minimum specified by the drawings. This condition had the effect of increasing the torque applied to the firing pin. The inner diameter of a torsion spring decreases slightly as it is wound to a position of maximum deflection. In this case, the coils would bind on the rotor shaft, hence creating a condition where only the last coil was producing the moment. Since the moment is inversely proportional to the number of turns, this resulted in a considerable increase in torque that was applied to the firing pin through the rotor. Consequently, greater torques, and hence higher wind velocities, were required to permit arming by the centrifugally operated clutch. For this reason, operability results of fuzes from this lot may have been degraded somewhat.

DESCRIPTION AND OPERATION OF THE ROCKEYE I WEAPON

6. The ROCKEYE I Cluster Bomb Mk 12 Mod 0 is an anti-tank, anti-personnel cluster weapon consisting of 96 shaped-charge bomblets which are dispersed after bomb release to give a large ground coverage. The weapon is used primarily against tanks, but is also effective against armored vehicles, personnel and fuel storage tanks.

7. The bomb, Figure 3, has an outer casing with streamlined end covers, inside of which a framework supports the bomblets in 16 sticks of six. At the center of the weapon a five-inch retro-rocket motor is positioned. The sticks are located symmetrically about the retro-rocket, eight on an inner radius, and eight on an outer radius. The total length of the weapon is 90 inches and the outer case diameter is 15.75 inches. The complete unit, including approximately 700 lbs of bomblets, will weigh 850 lbs.

8. After release from the aircraft, the bomb falls approximately one-half second before ignition of the retro-rocket. Upon ignition, the rocket exhaust removes the forward streamlined cover and the rocket is propelled rearward, withdrawing the bomblets and supporting structure from the case. After approximately 0.2 second, the bomblets are free of the outer case. At this time, by a camming action provided by the bomblet supports in conjunction with the rearward thrust of the rocket motor, the bomblets are propelled radially at a nominal speed of 10.5 ft/sec. Upon clearing the superstructure, the folded fins of the

lattermost bomblet opens and the increased drag separates it from the remainder of the bomblets in the stick. This sequence is repeated until all the bomblets have separated. Fuze arming commences upon separation from the stick, and after a predetermined time the bomblet becomes fully armed. The bomblets impact the ground in a pattern whose area depends upon the velocity and altitude of the aircraft at bomb release.

9. A modified service HEAT shaped-charge Rocket Head Mk 5 Mod 0 is used as the payload for the Cluster Bomb Mk 12. This is an in-service round which is used with the 2.75" FFAR rocket. The modification consists primarily of the addition of a folding fin arrangement which acts as a drag brake to reduce velocity of fall. The Mk 5 HEAT round contains 0.89 lbs of composition B explosive. The complete weight, including fins and fuze, is approximately 6.7 lbs. Figure 4 is a cutaway view of the round.

DESCRIPTION AND OPERATION OF THE FUZE

10. The Bomb Fuze Mk 258 Mod 0, Figure 1, is a vane-armed, point-initiating, base-detonating fuze. Operation of the fuze is as follows:

Upon separation from the weapon, the fuze vane is exposed to the wind stream which causes it to rotate. When the vane reaches a rotational speed of approximately 3500 rpm, centrifugal force causes the safety detents to move outward thus removing the block on the firing pin. The vane continues to accelerate and when a speed of approximately 7200 rpm is reached, the clutch moves outward, the tang engages the blade on the firing pin and removes it from the rotor. This action takes approximately 0.1 to 0.2 second depending upon the aircraft's release velocity. The rotor, under the force of a torsion spring, is then free to rotate toward the armed position. An annular gear, attached to the rotor, is engaged with the pinion of an escapement-and-gear subassembly which controls the rate of rotor motion. The rotor moves through an angular rotation of 117°, the last 15° of which it is disengaged from the annular gear. When the rotor reaches the armed position, a spring-loaded detent locks the rotor. The nominal arming time of the escapement controlled rotor is 1.45 seconds. Upon impact with a rigid target, such as a tank, the fuze ogive, vane and nut assembly, and firing pin are driven inward to initiate the Primer Mk 125 Mod 1. On impact with a soft target, such as ground, the fuze ogive will not be crushed. However, the force of the compacted earth acting on the vane assembly is sufficient to deform the four tabs supporting this assembly and the firing pin is driven into the primer. The primer initiates the explosive train consisting of a Detonator Mk 59 Mod 0, an RDX lead, and an RDX shaped-charge booster. The shaped-charge booster fires through the fire tube and initiates the booster in the base of the bomblet head. Significant safety features of the Fuze Mk 258 Mod 0 are:

a. The fuze provides a visible means of ascertaining the safe or armed condition of the explosive train.

b. Since a rotational speed of 7200 rpm is required to effect arming, the fuze cannot be armed by simply rotating the vane.

c. The fuze contains an interrupted explosive train wherein premature firing of the most sensitive explosive element will not initiate the main charge.

DESCRIPTION AND RESULTS OF TESTS

11. Mini Wind Tunnel. A facility was built with which the fuze could be operability tested (Figure 5). With it the fuze could be subjected to a measurable, repeatable blast of air. It includes an air flask, a solenoid actuated valve, and a small wind tunnel. The fuze is mounted to the end of the wind tunnel. Clamped to the body of the fuze is a microphone, the output of which is fed to a recorder. The sounds of the initial burst of air and the fuze rotor snapping into the armed position are indicated on the recorder record. The distance between these two events indicates the arming time, since the recorder paper speed is known. During a typical test the air flask is first filled with air at the desired pressure. Then the recorder is started, the valve is actuated, and after the fuze has armed, the recorder is stopped. Early tests indicated that a gage pressure of 35 psi is sufficient to reliably arm the fuze.

12. Temperature and Humidity Test. Ten fuzes from lot G were tested. Two were removed from the MIL-STD-304 Temperature and Humidity Test after exposure to it for seven days. The two fuzes were then operability tested on the mini wind tunnel at 35 psi air pressure. Both were operable, but only one arming time, 1.5 seconds, was obtained. The fuzes were then disassembled and inspected. Both had some corrosion at the assembly screws, skirt, arming vane, firing pin assembly, booster holder and lead holder. Three fuzes were removed from the test after exposure to it for 14 days. All three were operable when tested on the mini wind tunnel at 35 psi air pressure. One arming time was not obtained. The other two both armed in 1.6 seconds. The three fuzes were then disassembled and inspected. All had some corrosion at the assembly screws, skirt, arming vane, firing pin assembly, booster holder and lead holder.

13. Five fuzes were inspected after having completed the MIL-STD-304 Temperature and Humidity Test. All had some corrosion on the heads of the assembly screws and the top surfaces of the double detent assemblies. The fuzes were operability tested on the mini wind tunnel at 35 psi air pressure. One armed in 1.9 seconds. The remaining four had operable double detent

assemblies and clutches, and the firing pins were withdrawn. However, the rotors did not arm. The breakdown inspection revealed that the rotors did not arm because of corrosion in the gear trains. In addition, the fuzes all had some corrosion on the lead cups, booster holders, and firing pin housings. Since four of five fuzes were inoperable, it is concluded that the fuze failed this test.

14. Eight of these fuzes were later used for the firing train reliability tests described below. They were tested at ambient temperature. All fired high order.

15. Temperature Cycling. Ten fuzes from lot G were inspected after having been exposed to the dry temperature cycling specified in MIL-STD-304. Except for a slight film on top of the double detent assemblies, the fuzes all appeared undamaged. The fuzes were operability tested on the mini wind tunnel at 35 psi air pressure. All were operable. The arming times ranged from 1.4 to 1.7 seconds. A breakdown inspection of the fuzes revealed no damage except some slight corrosion on the lead cups. These fuzes were later used for the firing train reliability tests described below. They were tested at +160°F. All fired high order. Since the fuzes were all safe and operable, it is judged that they passed this test.

16. Salt Spray Test. Ten fuzes from lot H were subjected to the MIL-STD-306 Salt Spray Test. Seven were given the 48-hour test for operability and three were given the 96-hour test for safety. All ten fuzes emerged from the treatment with severe external corrosion and salt deposits. The operability test in the mini wind tunnel, first at 35 psi and then at 40 psi, resulted in all the ten fuzes being duds. The breakdown inspection revealed that all the clutches were cemented in place by corrosion and salt deposits. All except one (48-hour) of the double detent assemblies were inoperable due to corrosion and salt. All the firing pin assemblies were severely corroded. All the clocks were operable, however, except one of the 96-hour tested fuzes. All the fuzes were safe. Since none were operable, however, it is concluded that the fuzes failed this test.

17. Transportation Vibration Test. Ten fuzes from lot G were given the MIL-STD-303A Transportation Vibration Test. Three fuzes were given the test at +160°F, three at -65°F, and four at ambient temperature. After the treatment, the fuzes were operability tested in the mini wind tunnel at 35 psi air pressure. All were operable. Two arming times were not obtained. The other eight arming times ranged from 1.50 to 1.70 seconds. The fuzes were then disassembled and inspected. No damage was

seen. These fuzes were later used for the firing train reliability tests described below. They were tested at -65°F. All fired high order. Since the fuzes all remained safe and operable, it is concluded that they passed this test.

18. Sequential Tests. Five fuzes from lot G were subjected to sequential tests consisting of the dry temperature cycling specified in the MIL-STD-304 Temperature and Humidity Test, followed by the MIL-STD-303A Transportation Vibration Test at ambient temperature. After the treatment, the fuzes were operability tested in the mini wind tunnel at 35 psi air pressure. Four armed, with arming times ranging from 1.50 to 1.60 seconds. One failed to arm. A second attempt was made to arm this fuze, at 40 psi air pressure. It again failed to arm. The fuze was disassembled and inspected. The extension tab on top of the firing pin was found to be loose. Also, the slot on the tab was not in line with the slot on the firing pin. This condition could prevent the clutch from contacting the firing pin, and thus cause a dud. Since the tab on the firing pin is not part of the fuze design, it is considered that this dud should be ignored. The other four fuzes were disassembled and inspected. No noteworthy damage was found. Two of these fuzes were later used for the firing train reliability tests described below. They were tested at ambient temperature. Both fired high order. Since the four fuzes remained safe and operable, it is concluded that the fuze passed this test.

19. An additional group of five fuzes from lot G was given sequential tests consisting of the MIL-STD-303A Transportation Vibration Test followed by the dry temperature cycling specified in the MIL-STD-304 Temperature and Humidity Test. During the transportation vibration test, two fuzes were vibrated at -65°F, two at +160°F, and one at ambient temperature. After the treatment, the fuzes were operability tested in the mini wind tunnel at 35 psi air pressure. Four armed, with arming times ranging from 1.40 to 1.45 seconds. One failed to arm. This fuze had been vibrated at -65°F. A second attempt was made to arm this fuze, at 40 psi air pressure. It again failed to arm. An inspection revealed that the firing pin was jammed against the bottom of the double detents. The clutch had functioned, but the double detent assembly had not. The five fuzes were disassembled and inspected. No noteworthy damage was found.

20. Aircraft Vibration Test. The NOL Aircraft Vibration Test consists of two parts; a high frequency part, and a low frequency part. The low frequency part consists of simple harmonic excitation applied parallel to each of the three principal axes of the fuze. The frequency range of 10 to 50 cycles per second is covered by cycling in 24 discrete frequency

steps which have a logarithmic distribution. The fuze receives an acceleration of 2.0 ± .2 g's. The test duration is four hours in each orientation, for a total low frequency test time of 12 hours. The high frequency part consists of simple harmonic excitation applied to each of the three principal axes of the fuze. The frequency range of 60 to 500 cycles per second is covered by cycling at a logarithmic rate of one octave per minute. The fuze receives an acceleration of 3.0 ± .3 g's. The test duration is 15 minutes in each orientation, for a total high frequency test time of 45 minutes.

21. Ten fuzes from lot H were subjected to the NOL Aircraft Vibration Test. Three were tested at -65°F, three were tested at +160°F, and four were tested at ambient temperature. The fuzes appeared to be undamaged from the treatment. The operability check in the mini wind tunnel at 35 psi resulted in eight that armed, with arming times from 1.52 to 1.70 seconds, and two duds. A second attempt was made to arm the two dud fuzes, this time with 40 psi air pressure. Both armed, with arming times of 1.62 and 1.66 seconds. Since the fuzes were all undamaged and operable, it is judged that they passed this test.

22. Stockpile-to-Target Tests. Ten fuzes from lot G were subjected to sequential tests consisting of the MIL-STD-353 Transportation Vibration Test followed by the dry temperature cycling specified in the MIL-STD-304 Temperature and Humidity Test followed by the NOL Aircraft Vibration Test. After the treatment, the fuzes were operability tested in the mini wind tunnel at 35 psi air pressure. Eight armed, with arming times varying from 1.45 to 1.60 seconds. Two did not arm. A second attempt was made to arm these two fuzes, this time with 40 psi air pressure. Neither armed. The two fuzes were disassembled and inspected. No damage was seen that would explain their failure to arm. The eight operable fuzes were also disassembled and inspected. No damage was seen. Since two fuzes did not arm, it is concluded that this treatment may degrade the operability of the fuze.

23. Detonator Safety Tests. MIL-STD-315 Detonator Safety Tests were conducted with 30 fully loaded fuzes from lot G. The primers were fired by a falling weight impacting a firing pin which extended through a hole in the fuze body and rested against the primer. Figure 6 shows the fixture used to drill the holes in the fuze bodies.

24. The primers were fired with the rotors in the fully safe position. Ten fuzes were tested at +160°F, ten at ambient, and ten at -80°F. In all cases, there was no burning or melting of the RDX lead or booster. All the fuzes emerged with the flange

on the lead bowed downward and the booster pushed outward from .017 inch to .026 inch. All the bodies fractured at the threads opposite the detonator. In about half of the fuzes, small pieces of the shoulder inside the body were broken off. One fuze tested at ambient temperature emerged with the booster holder slanted in the body, and extending a maximum of 1/8 inch. The body of one fuze tested at -80°F split, opened up about 1/8 inch, and the lead and booster holder came out. The shoulder inside another fuze tested at -80°F sheared off, and the firing pin assembly blew out. The vane was not dented, however, indicating a low velocity. It is judged that the damage observed during these tests would not cause serious injury or death to personnel, and that the fuze therefore passed this test.

25. Firing Train Reliability Tests. Thirty fuzes from lot G were given firing train reliability tests. The armed fuzes were fired by the impact of a one inch diameter steel rod two feet long falling approximately two feet. Figure 7 illustrates the firing arrangement. These fuzes had previously been given the temperature and humidity, temperature cycling, transportation vibration and sequential tests described above. Ten fuzes were tested at ambient temperature, ten at -65°F, and ten at +160°F. High order firing of the booster was indicated by the puncturing of a 1/8 inch thick steel plate. All the fuzes fired high order. All the indicator plates were punctured. It is therefore concluded that the fuze passed this test.

26. Jolt Test. Twenty fuzes from lot G were given the MIL-STD-300 Jolt Test. The assembly screws of three fuzes loosened and came out. All three armed during the test, and one fired. A second fuze that armed had the primer opened by the firing pin, but it did not fire. Since three fuzes armed during the test, and one of these fired, it is concluded that these fuzes failed this test.

27. A modification to enable the fuze to pass the jolt test was tested. The modification, represented by lot I, consisted of washers soldered to the under sides of the assembly screw heads. After the screws are tightened, the washer tabs are bent over the edge of the double detent assembly. This prevents the assembly screws from turning. Ten fuzes with this modification were given the MIL-STD-300 Jolt Test. All remained safe. One fuze emerged from the test with a loosened firing pin assembly because three of the assembly plate tabs broke off. This fuze was removed from the group and the remaining nine fuzes were given a second MIL-STD-300 Jolt Test. All remained safe. It is therefore concluded that these fuzes passed this test.

28. Jumble Test. Twenty fuzes from lot G were given the MIL-STD-301 Jumble Test, after which ten were disassembled and inspected. The rotor firing pin holes were slightly elongated. Two fuzes had loose detonators in the rotors. In one case, the button on the end of the firing pin had loosened and moved up. The remaining ten fuzes were given an additional MIL-STD-301 Jumble Test, after which they were inspected. In general, the fuzes suffered worn assembly plate tabs and slightly elongated rotor firing pin holes. In six cases the booster holder stakes loosened sufficiently to allow the booster holder to be rotated from 1/8 to 1/4 inch. The end of the rotor pinion gear rack broke off in two cases. Since all the fuzes remained safe, it is concluded that they passed this test.

29. Forty-Foot Drop Test. MIL-STD-302 Forty-Foot Drop Tests were conducted with ten fully loaded fuzes from lot G assembled in inert bomblets. Two drops were made in each of the five specified orientations. In all cases, there was some bending of the assembly plate tabs. The shroud was broken off in four cases, and part of the shroud was broken off in three cases. The firing pins did not separate from the fuzes. The rotors did not arm. The firing pins of the two nose down samples were driven into the rotor, and the booster holder and lead came out of one of them. All the fuzes remained safe for disposal purposes, and none of the explosives burned or detonated. It is therefore judged that the fuze passed this test.

30. Five-Foot Drop Test. MIL-STD-358 Five-Foot Drop Tests were conducted with ten fuzes from lot H assembled in inert bomblets. Two drops were made in each of the five specified orientations. Both nose down, both 45° nose down, and one of the horizontal samples suffered broken, split or bent shrouds. The others suffered little or no external damage. The fuzes were operability checked in the mini wind tunnel at 35 psi air pressure. Seven failed to arm. The three operable ones had arming times of 1.39, 1.40 and 1.41 seconds. A second attempt was made to arm the seven fuzes, at 40 psi air pressure. None of them armed. Three were inoperable because of bent shrouds, which prevented the vanes from turning. In another three fuzes, the firing pin was found jammed against the clutch. In the seventh dud, the firing pin armed, but the rotor didn't turn. This rotor later armed while the fuze was being disassembled. Since seven fuzes were inoperable, it is judged that they failed this test.

31. Timing Tests. Timing tests were conducted with 20 timing mechanisms from lot F. The tests were conducted at ambient and temperature extremes with the fixture illustrated in Figure 8. At ambient temperature, the arming times ranged from 1.31 to 1.47 seconds, with a mean of 1.40 and a standard

deviation of 0.04 seconds. At +160°F, the arming times varied between 1.44 and 1.64 seconds, with a mean of 1.54 and a standard deviation of 0.05 seconds. At -65°F, the arming times ranged from 1.44 to 1.54 seconds, with a mean of 1.50 and a standard deviation of 0.03 seconds.

32. Storage at -80°F. Five fuzes from lot H were stored at -80°F for 72 hours and then inspected at ambient temperature. The operability check in the mini wind tunnel at 35 psi air pressure resulted in two arming, with arming times of 1.39 and 1.43 seconds, and three failing to arm. The three that didn't arm were retested at 40 psi air pressure. One armed, with an arming time of 1.55 seconds, and two didn't. The fuzes were disassembled and inspected. No damage was seen. Since two fuzes didn't arm and a third almost didn't, it is concluded the operability of the fuze is degraded by this treatment.

33. Extreme Temperature Storage Test. Ten fuzes from lot G were given extreme temperature storage tests. Five were subjected to -65°F for 28 days followed by +160°F for 28 days, and five were subjected to +160°F for 28 days followed by -65°F for 28 days. After the treatment, the fuzes were operability tested in the mini wind tunnel at 35 psi air pressure. All armed. One arming time was not obtained. The other nine arming times ranged from 1.40 to 1.60 seconds. The fuzes were then disassembled and inspected. No damage was seen. Since all were undamaged and operable, it is concluded that the fuzes passed this test.

34. Operation at Temperature Extremes. Operability tests at temperature extremes were conducted with fuzes from lot H. The tests were conducted in the mini wind tunnel with 35 psi air pressure. Ten fuzes tested at -65°F resulted in one dud and nine that armed. The arming times ranged from 1.40 to 1.64 seconds, with a mean of 1.54 and a standard deviation of 0.08 seconds. Ten fuzes tested at +160°F resulted in two duds, and eight that armed with times ranging from 1.48 to 1.64 seconds, with a mean of 1.58 and a standard deviation of 0.06 seconds.

35. Minimum Arming Velocity. Wind tunnel tests were conducted to determine the minimum arming velocities of a group of ten fuzes from lot H. Starting with an air velocity of 150 knots, the lowest obtainable, the test velocity was increased in 10 knot increments until all the fuzes armed. The velocity for each test was computed from instrument readings obtained during the test. The arming velocities ranged from 176 to 208 knots. The individual minimum arming velocities, in knots, were as follows: 176, 177, 183, 189, 194, 194, 202, 202, 202 and 208.

36. Package Evaluation. A package evaluation was conducted with 20 fuzes from lot H randomly distributed within the package. Since the package is designed for 48 fuzes, the remainder of the positions were occupied by fuzes of an older design. The package was first dropped 30 inches a total of six times; once on each of four corners, on the bottom, and on an end. The package was then jostled on a platform one-half hour on each of its six faces, for a total of three hours. The package emerged from the test with only slight dents on the corners from the drops. No damage was seen to the inner containers or the fuzes. The 20 fuzes were then operability tested in the mini wind tunnel, at 35 psi air pressure. Seventeen armed, with times ranging from 1.54 to 1.70 seconds. Three were duds. A second attempt was made to arm the three dud fuzes, again with 35 psi air pressure. Two armed, with arming times of 1.58 and 1.62 seconds. Since the package remained intact and continued to protect its contents, and since the fuzes remained safe and almost all were operable, it is concluded that both the package and fuzes passed this test.

37. Penetration Tests. A total of 55 tests were conducted at NWL against 10 inch class B armor, to determine the operability of the fuze. The rounds consisted of fuzes from lot E, 2.75 inch Heads Mk 5 Mod 0 modified with phenolic sleeves to fit the air gun, and aluminum end caps from cluster bomb fin assemblies. The rounds were all fired from an air gun designed and built by NOL(WO). The air gun is shown in Figure 9. Those fuzes tested at 900 ft/sec were modified to withstand air gun accelerations. The modification consisted primarily of a 0.010 inch spring brass washer under the assembly plate. The test velocities varied from 200 to 900 ft/sec and the obliquities varied from 0 to 70 degrees. Of the 42 that were operable, 23 had penetrations less than seven inches. The following table summarizes the results:

Velocity Ft/Sec.	Obliquity (Degrees)	Result Functioned/ Tested	Penetration Range (Inches)	Penetration Less Than 7 In.
200	0	9/9	$5\frac{1}{2}$-$9\frac{1}{2}$	3
200	70	0/2		
200	60	6/8	$3\frac{1}{2}$-7-3/4	5
900	0	9/9	6-3/4-8-3/8	1
900	70	2/5	7-3/8-8	0
900	60	0/4		
900	50	8/10	5-1/8-8	6
650	60	8/8	4-3/4-6-3/4	8

38. Sensitivity Tests. Air gun sensitivity tests were conducted at NOL with fuzes from lot H. The rounds consisted of service loaded fuzes in inert heads. The threads of the steel thread adaptors were removed and the adaptors were cemented to the heads. Functioning of the fuze was indicated by the thread adaptor being blown off. Five fuzes tested against 1/16 inch steel targets at 0° obliquity and 200 ft per second velocity all functioned. Five tested against 1/16 inch steel targets at 70° obliquity and 200 ft per second velocity resulted in three that functioned and two duds. The two duds were caused by the rounds glancing off the targets and not penetrating them. Five fuzes tested against 1/16 inch steel targets at 0° obliquity and 900 ft per second velocity all functioned. Five fuzes tested against 1/16 inch steel targets at 70° obliquity and 900 ft per second velocity all functioned. Five fuzes tested against water at 0° obliquity and 200 ft per second velocity all functioned.

39. Accidental Release Test. A MIL-STD-311 Accidental Release Test was conducted at the NOTS B-1 Range. The weapon was dropped onto a macadam surface from a YA-4C aircraft flying at an altitude of 100 feet and a velocity of 160 knots. The weapon contained inert bomblets and 30 fuzes from lot F, with primers and detonators, randomly distributed within the weapon. Upon impact, the weapon broke open and the bomblets were scattered over a large area. Damage to the fuzes varied from slight to severe. Eight fuzes armed because the shrouds and firing pin assemblies were broken off. Without the firing pins, the spring loaded rotors were free to arm. An additional six suffered broken off shrouds and firing pin assemblies, but these either partly armed or remained safe. None of the fuzes fired.

40. Impact Safety (Armed Rotor). At NOL, tests were conducted to determine the seriousness of the fuze forward section being wiped off and the rotor arming in the dud weapon situation. These fuzes, from lot F, were samples actually recovered from a NOTS drop during which the weapon failed to open. Five of the fuzes had actually been damaged and armed during the drop, as described above. The fuzes had primers and detonators, had armed rotors, and were without forward sections. The tests were conducted in inert loaded Heads Mk 5. Seven rounds were dropped nose down a distance of 40 feet into sand. None of the primers fired. The impact velocity was approximately 50 feet per second. The assembly plates were removed, and additional tests were conducted. Three drops into sand were all duds. A layer of crushed stone several inches thick was placed on top of the sand. Three drops onto this target were all duds. The crushed stone and sand were then mixed together, and four drops were made into this target. All were duds.

41. At NOL, air gun safety tests were conducted with lot E fuzes to investigate the unsafety of the fuze if it should arm in the accidental release situation. The tests were conducted at approximately 160 knots velocity. The fuzes were armed and without firing pin assemblies or assembly plates. They contained primers and detonators, but no leads or boosters. Two fuzes were tested against three inch steel. Both fired. Both fuzes tested against three inch concrete fired. Two fuzes tested against $1\frac{1}{2}$ inch wood did not fire. Four fuzes tested against sand did not fire.

42. Impact Safety Tests (Safe Fuze). Tests were conducted at NWL with fuzes from lot E to determine the impact safety of the fuze. The tests were conducted against 10-inch class B armor with service loaded fuzes and heads. Two rounds tested at 160 knots and zero degrees obliquity, with the fuze in the safe condition, were both duds. An additional two rounds with fuzes in the safe condition were fired in tandem against a 10-inch armor target at zero degrees obliquity, and approximately 160 knots velocity. The purpose of the test was to determine the likelihood of a round firing in the accidental release situation, where rounds in tandem may be telescoped together. Although there was some damage to the rear round and very severe damage to the front round, none of the explosives fired.

43. Jettison Safety Test. A MIL-STD-307A Jettison Safety Test was conducted at the NOTS B-2 Range. The weapon was dropped from a YA-4C aircraft flying at an altitude of 15,000 feet above the ground and a velocity of 350 knots. The weapon contained 30 service loaded fuzes from lot F assembled to five complete "sticks" of bomblets. All 96 bomblets in the weapon were service loaded. An explosion occurred upon impact of the weapon with the ground. A large hole was formed, approximately 15 feet in diameter and five feet deep. A number of bomblet pieces were scattered within the crater and in the immediate vicinity. It appeared that the bomblet explosives fired low order.

44. Arming Time Tests. Arming time tests were conducted at the NOTS B-1-B range. Thirty fuzes from lot H were tested in each of two weapons, which were released from a YA-4C aircraft. The fuzes and bomblets were modified to actuate a smoke puff on arming. A brass button was cemented to the detonator with conductive cement. The lead holder was removed, and a phenolic disc with a brass screw protruding through its center was substituted for it. When the rotor armed, the button on the detonator made contact with the insulated screw in the phenolic disc. This served as the "switch" to fire the smoke puff. Figure (10) describes the arrangement. The fuze "switch" was in series with a battery and primer. The primer was made at

NOL for the test. It was a special 3000 erg primer with a 50 mg DDNP bridge wire mix and a 150 mg lead styphnate base charge. The primer was imbedded in a package with about 5 grams of FFFG black powder, for reliable initiation of the smoke puff charge. The smoke puff charge was a mixture of 2/3 MIL-D-3284 Dye and 1/3 FFFG black powder, by weight. Included in the circuit was a lanyard operated safety switch, for safety during handling. It shorted the primer and isolated it from the circuit. The lanyard was tied to the bomblet supporting framework of the weapon, and actuated the switch when the bomblet was ejected from the framework.

45. One weapon was released in a five degree dive, at an altitude of 400 feet and a velocity of 500 knots. Fuze arming occurred later than was expected, and the bomblets impacted the ground before all the fuzes had armed. Fourteen clearly distinguishable puffs were seen on the film record, with arming times ranging from 2.507 to 2.819 seconds. One ground impact was seen at 2.507 seconds, the same time as the first puff, but the second ground impact was at 2.610 seconds, by which time 10 aerial puffs had been seen. The aircraft was out of the field of view when the first puff was seen, but since there was over 240 feet from the puff to the corner of the picture, there was safe separation.

46. The second weapon was released from level flight at an altitude of 250 feet and a velocity of 250 knots. Here too, the bomblets impacted the ground before all the fuzes had armed. Seven puffs were seen on the film record, with arming times ranging from 2.987 to 3.816 seconds. The first ground impact was observed at 3.777 seconds. The aircraft was out of the field of view when the first puff was seen, but since there was over 200 feet from the puff to the corner of the picture, there was safe separation.

47. <u>Fly-Around Tests</u>. Twenty fuzes from lot F were given fly-around tests at NOTS. Ten fuzes were at the front of the weapon and ten were randomly distributed. The test was conducted without the nose fairing, but with the windshield and nose support. The four one-hour flights included altitudes up to 31,000 feet, maximum velocities of 540 knots, dives, and pullouts giving a maximum of four g's. After the second flight, it was noted that the windshield had slipped but was held on the weapon by the nose support. None of the fuzes had armed. However, two fuzes armed during the third flight, and a third armed during the fourth flight. It was desired that the fuzes be returned to NOL for inspection. However, they were accidentally destroyed, making an inspection impossible.

48. Operability Versus Ground. Fifty-six fuzes from lots F and G were operability tested against ground at NOTS. The fuzes contained primers and detonators. The bomblets were inert. The weapon was dropped from an A-4C aircraft flying horizontally at an altitude of 280 feet and a velocity of 250 knots. An examination revealed that 44 fuzes fired and 12 were duds.

49. A second operability test against ground, with 52 fuzes from lot G was conducted at NOTS. This weapon also contained inert bomblets, and fuzes with primers and detonators. The weapon was dropped from an A-4C aircraft in a 15-degree dive at an altitude of 700 feet and a velocity of 350 knots. An examination revealed that 46 fired and six were duds.

50. Three service loaded ROCKEYE I weapon tests were conducted at the Airport Lake range at NOTS, with fuzes from lots G and H, against simulated convoys. The convoys consisted of vehicles arranged in a diamond pattern, with a tank at the center. Pine boxes were strewn throughout the area to simulate prone men. Each weapon was released from a 10° dive at an altitude of 700 feet and a velocity of 450 knots. The tank was missed in every case, but extensive damage to the pine boxes was reported. There were 23 fuze duds, from the 288 rounds.

DISCUSSIONS AND CONCLUSIONS

51. As can be seen from the Flow Chart (Figure 2), the evaluation program for the ROCKEYE I Bomblet Fuze Mk 258 Mod 0 included an assortment of safety, environmental and operability tests. The results from most tests were acceptable. Table 1 briefly lists the results from the various tests. Some of the more important fuze properties are discussed in the following paragraphs.

52. Penetration. Since this is an anti-tank weapon, armor penetration is important. The fuze is required to initiate the shaped charge upon impact so that a minimum of seven inches penetration, at 0 degrees obliquity, of rolled homogenous armor plate is obtained under dynamic firing conditions. The penetration tests included 18 rounds at 0 degrees obliquity; nine were at 200 ft per second and nine were at 900 ft per second velocity. All 18 fuzes functioned. Four of the penetration distances were less than seven inches, so the fuze does not quite meet this objective.

53. Impact Angles and Velocity. The armed fuze is required to detonate the shaped charge upon impact with armor, water and thin steel at angles up to 70 degrees from the normal, and at velocities from 200 to 900 ft per second. The fuze was operable

against water at 200 ft per second velocity and zero degrees obliquity, and is probably operable against it at 70 degrees obliquity and 900 ft per second velocity. Against 1/16 inch steel, tests showed the fuze to be operable at 900 ft per second velocity and zero and 70 degrees obliquity. However, tests at 200 ft per second velocity showed the fuze to be operable at zero degrees obliquity but only partly operable at 70 degrees, since two of five rounds tested glanced off the target and did not function. Against armor, the fuze was operable at zero degrees and both 200 and 900 ft per second velocity, but not at 70 degrees obliquity, since two rounds tested at 200 ft per second were both duds, and five rounds tested at 900 per second velocity resulted in three duds and two operable fuzes. The operability against armor is greatly improved at reduced angles of obliquity. At 200 ft per second and 60 degrees, six of eight rounds tested functioned. At 900 ft per second and 50 degrees obliquity, eight of ten rounds tested functioned. It is considered that the fuze only partly meets this objective.

54. Sensitivity. The fuze is required to be sensitive enough so that an impact with 1/16 inch steel, at velocities from 200 to 900 ft per second, will detonate the shaped charge. The fuze does function reliably against 1/16 inch steel at zero degrees obliquity. Five rounds tested at 200 ft per second and five rounds tested at 900 ft per second all functioned. At 70 degrees obliquity and 200 ft per second velocity, two duds of five rounds tested were obtained because the rounds glanced off the targets. These duds were therefore due to the geometry and ballistics involved, and not to insufficient sensitivity. It is considered that the fuze meets this objective.

55. Reliability. The field tests included five weapon drops with a total of 396 fuzes being tested. Forty-one duds were obtained. The observed reliability is therefore approximately 90 percent. However, the results of the arming time tests revealed that the arming time is longer than was thought, so some of the observed duds may have been due to the fuzes not having sufficient time to arm before impacting the ground. The overall reliability of the fuze is directly dependent upon satisfactory performance of the weapon. During the development and evaluation programs a number of weapon drops were observed wherein bomblet ballistics were unstable, and where some bomblets failed to separate properly and impacted the ground as doublets or triplets. Since the fuze is vane armed, proper functioning is governed by stable bomblet flight. If unstable bomblet ballistics occurs, longer arming times can be expected. Naturally, if the bomblets fail to separate, the fuzes cannot sense the wind and duds will occur.

56. General Safety. The fuze is required to have safety and arming features such that the probability of an accidental detonation of the bomb is 10^{-6} or less during storage, transportation, handling, fuze or bomb loading (or unloading) and aircraft flight. The evaluation program included several safety tests during which the fuze performed poorly. The MIL-STD-311 Accidental Release Test resulted in eight fuzes arming, of 30 fuzes tested. Impact safety tests to explore the seriousness of this problem disclosed that fuzes so armed may fire upon impacting steel or concrete targets. The MIL-STD-307A Jettison Safety Test resulted in the weapon exploding. However, it is suspected that this was due to the bomblets, rather than the fuzes. The fly-around tests revealed that fuzes may arm if the nose fairing is lost. These limitations can be improved in service use by establishing the following restrictions:

a. Jettison the weapon only in safe areas.

b. Prohibit aircraft return to carriers with ROCKEYE I weapons aboard.

57. Electromagnetic Radiation Hazards. In common with all Navy fuzes, this fuze is required to be safe during bomb handling and loading, when exposed to highpowered electromagnetic radiation from shipboard communication and radar equipment. No test was performed to demonstrate compliance with this objective. However, this is a mechanical fuze, no part of which depends upon electrical energy for its operation. It is also almost completely shielded while within the weapon. It is therefore considered that the fuze meets this requirement.

58. Sealing. The fuze is not sealed, and the bare fuze failed the MIL-STD-304 Temperature and Humidity Test, since four were inoperable of five fuzes tested. It also failed the MIL-STD-306 Salt Spray Test, since ten samples were all inoperable after the test. The design of the Fuze Mk 258 Mod 0 was based on the philosophy that it is more economical to provide sealing of the weapon case (one seal) than to try and seal 96 individual fuzes. The packaging of the fuze was designed to afford adequate protection from the time of manufacture until assembly into the weapon. Thereafter, protection from the environments would be accomplished by the weapon. The fuze therefore was not expected to pass the more severe environmental tests such as MIL-STD's 304 and 306. These tests were, however, conducted for information purposes to obtain a measure of the bare fuze resistance to corrosive atmospheres. The fuze is therefore considered acceptable in this respect.

59. Other Environments. The fuze should be capable of operation under the following environments: atmospheric pressure from 15.4 to 7.34 psi (corresponding to an altitude of 18,000 feet), temperature shock, fungus and icing. Although no tests were conducted to check fuze operation under these environments, a discussion of them may be of interest. Since the fuze is air armed, the atmosphere is necessary for arming. The impulse on the vane is a function of the density of the air. It therefore, seems reasonable to assume that arming problems may be expected with targets at high altitudes. If released at high altitudes against targets at low altitudes, the bomblets must pass through the atmosphere of essentially sea level density before hitting the target. Therefore the fuzes should arm satisfactorily even though the arming times would perhaps be long. Temperature shock is not expected to cause any serious problems. The MIL-STD-304 Temperature Cycle to which the fuze was subjected included some temperature shock, and the fuze passed that test. Fungus requires both humidity and organic materials. The only organic material in the fuze is a small piece of paper next to the lead. A slight amount of fungus here will be harmless. The humidity will have to be kept low, anyway, to prevent damage from that cause. Icing will cause duds, since ice on any moving part will cement that part and prevent it from moving. However, water is necessary for the formation of ice. Since the fuze will be kept dry, first by the package and then by the weapon, no icing problems are expected.

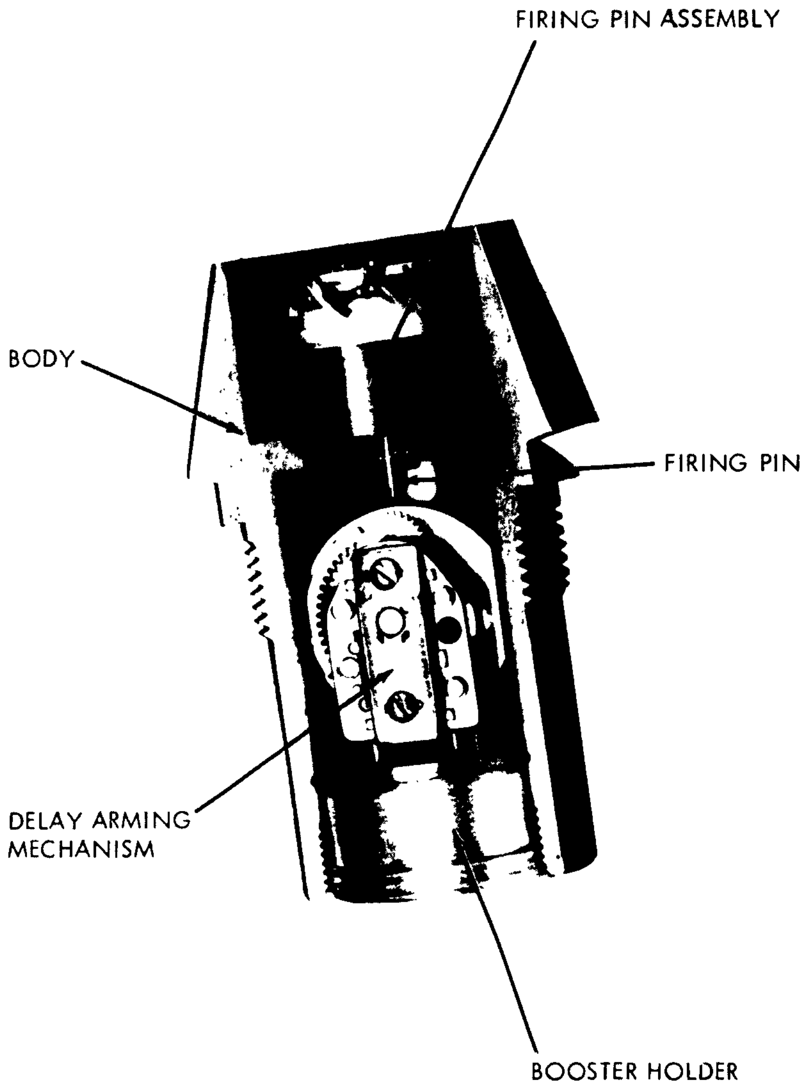
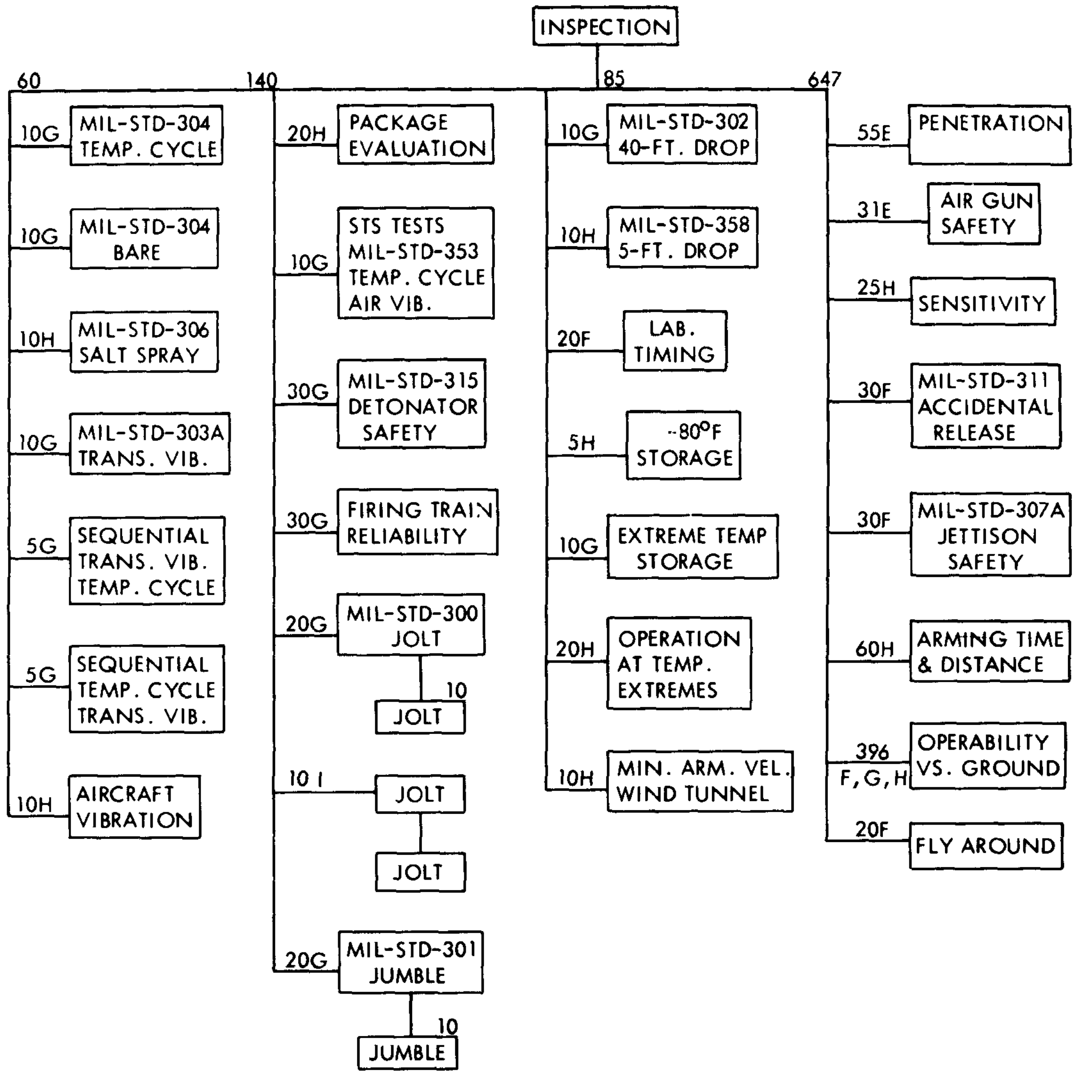


Fig. 1 FUZE MK 258 MOD 0 CUTAWAY VIEW



NOTE: LOT E - HAS NO DOUBLE DETENT ASSEMBLY. HAS SMALL TIP ON TOP OF FIRING PIN.

LOT F - HAS DOUBLE DETENT ASSEMBLY. SCREWS COMENTED WITH GLYPTAL. HAS IMPROVED ASSEMBLY PLATE STAKE. TIP OF FIRING PIN REMOVED.

LOT G - LIKE LOT F, BUT HAS 0.035 INCH ALUMINUM EXTENSION ON FIRING PIN. ASSEMBLY SCREWS CEMENTED WITH EPON 828.

LOT H - LIKE LOT G, BUT HAS LONG ONE PIECE FIRING PIN. HAS DEEPER NUT THREADS.

LOT I - LIKE LOT H, BUT HAS WASHERS SOLDERED TO UNDER SIDE OF ASSEMBLY SCREW HEADS.

Fig. 2 FLOW CHART, FUZE MK 258 MOD 0 EVALUATION

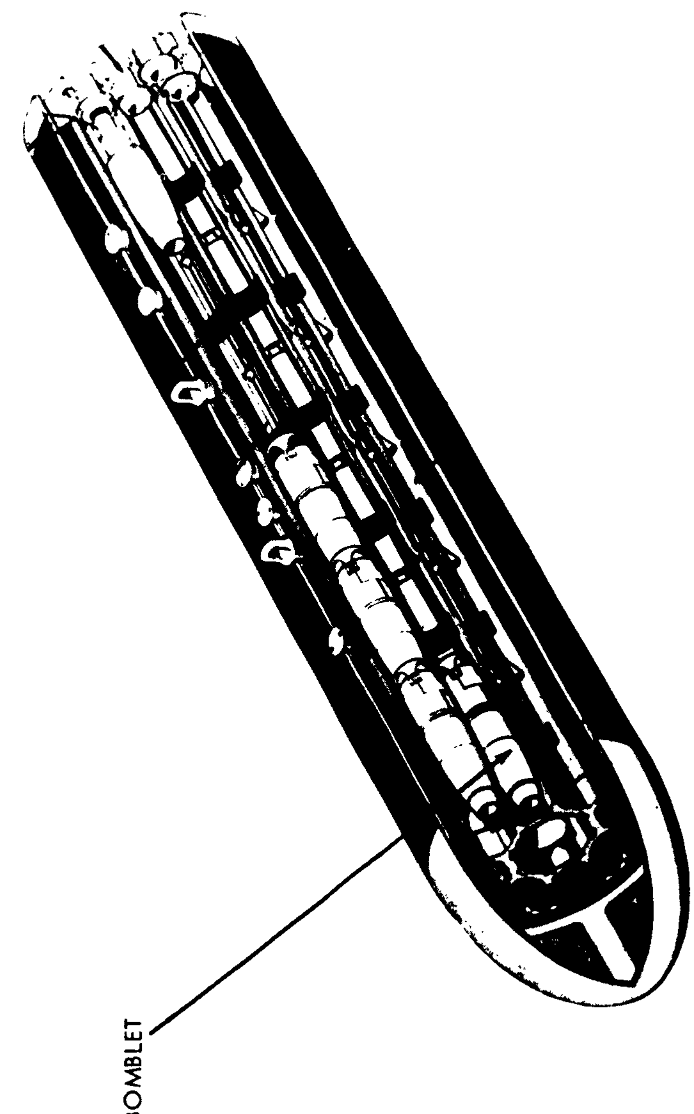


Fig. 3 CLUSTER BOMB MK 12 MOD 0, CUTAWAY VIEW

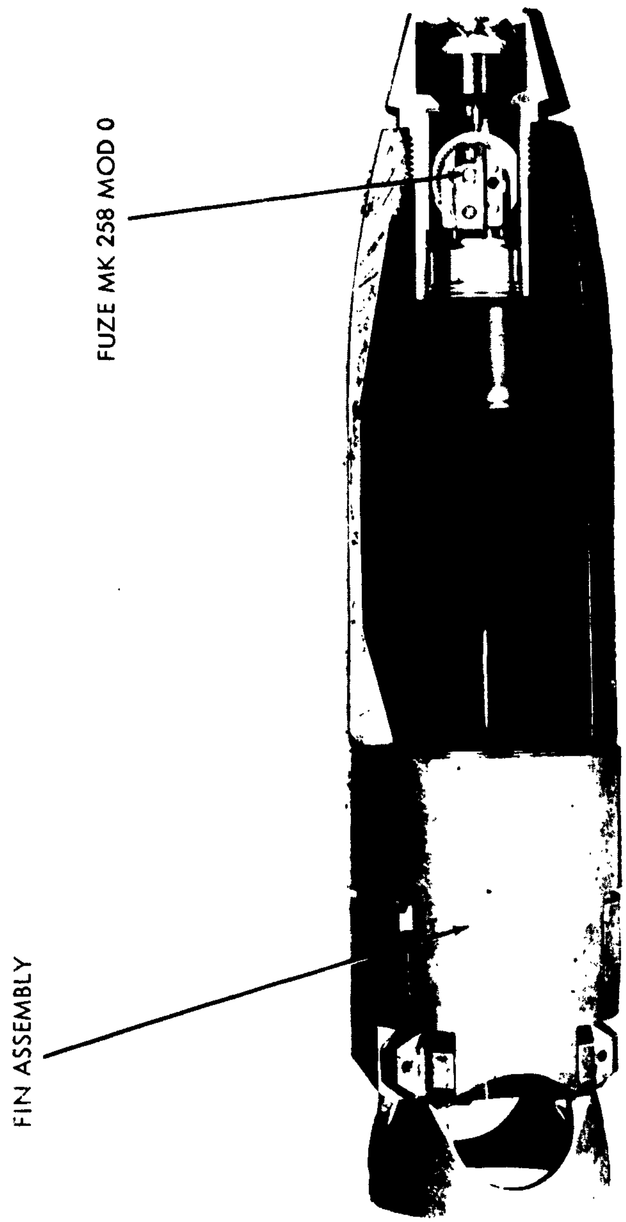


Fig 4 ROCKEYE I BOMBLET, CUTAWAY VIEW

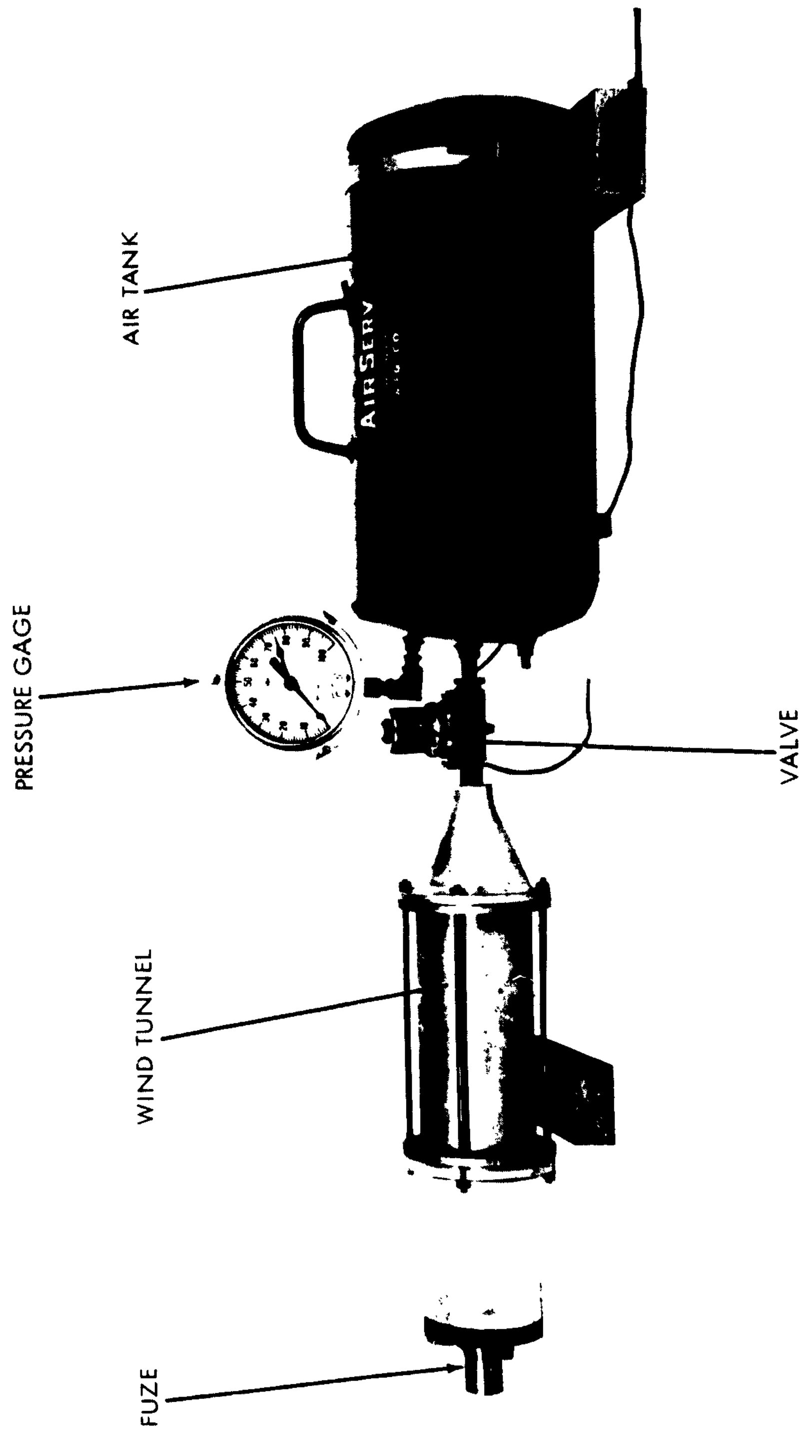


Fig. 5 MINI WIND TUNNEL

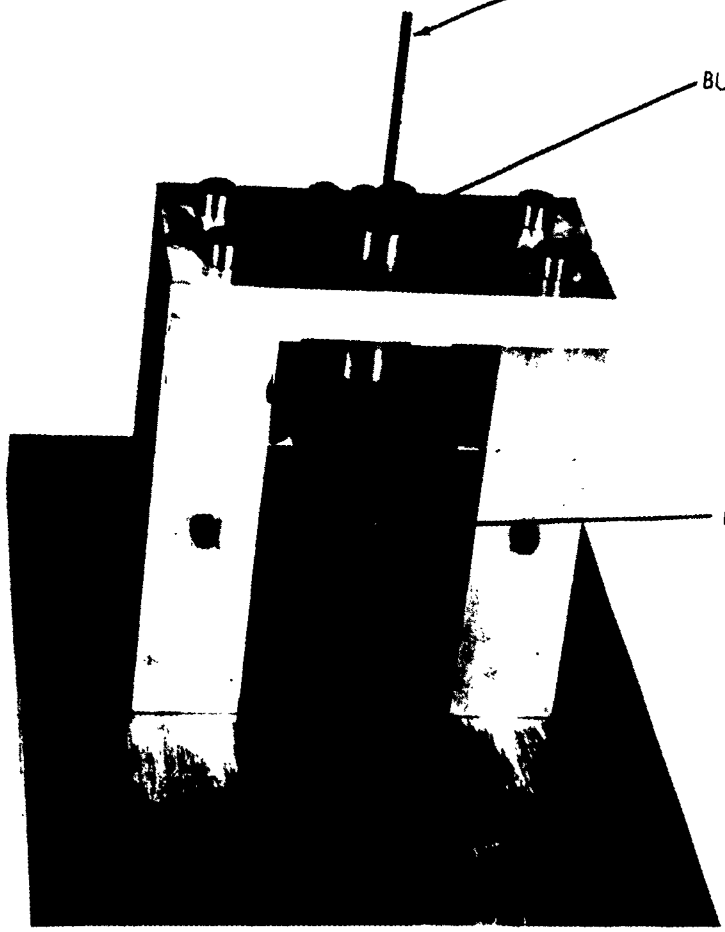


Fig. 6 BODY DRILLING FIXTURE

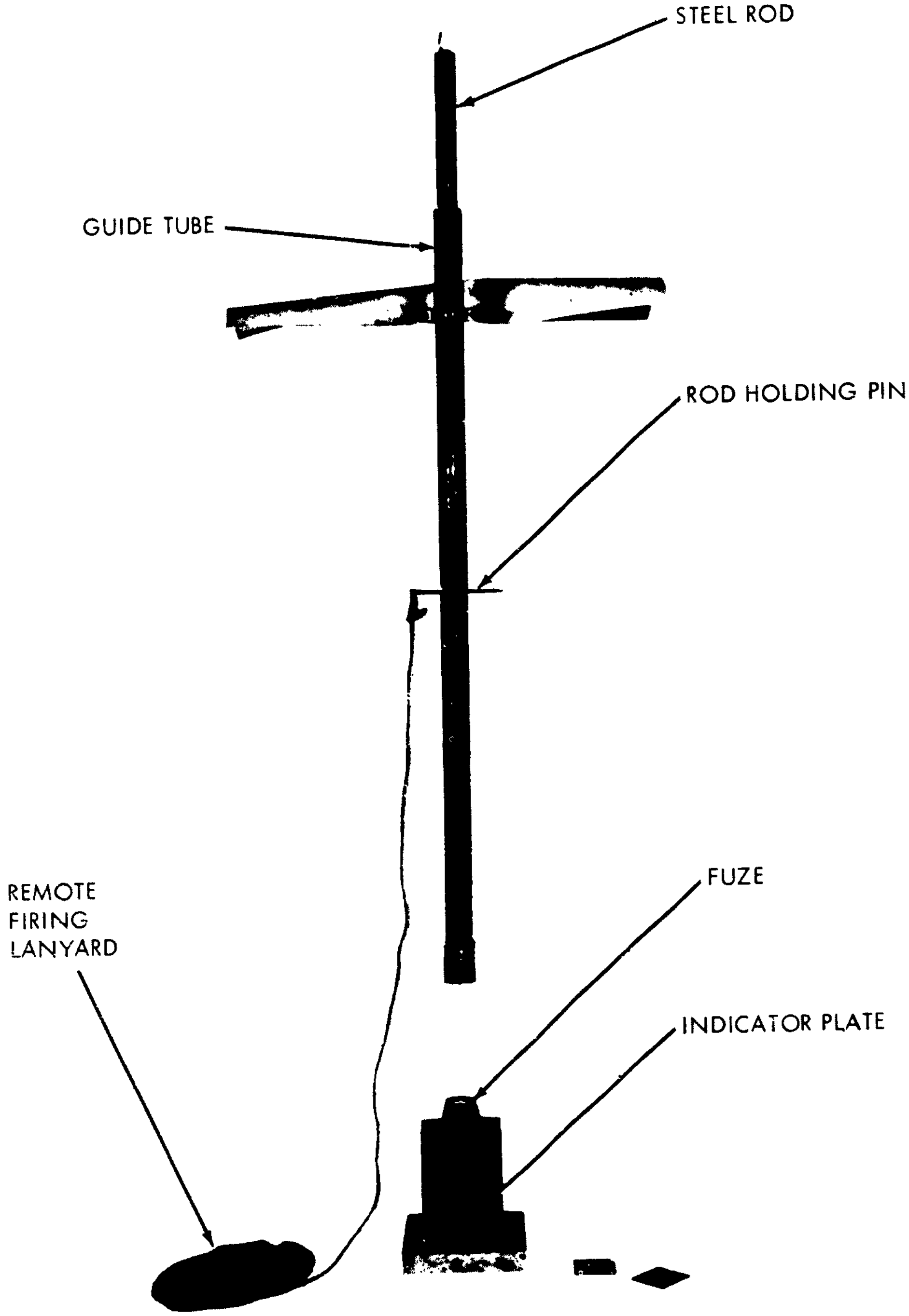


Fig. 7 FIRING ARRANGEMENT

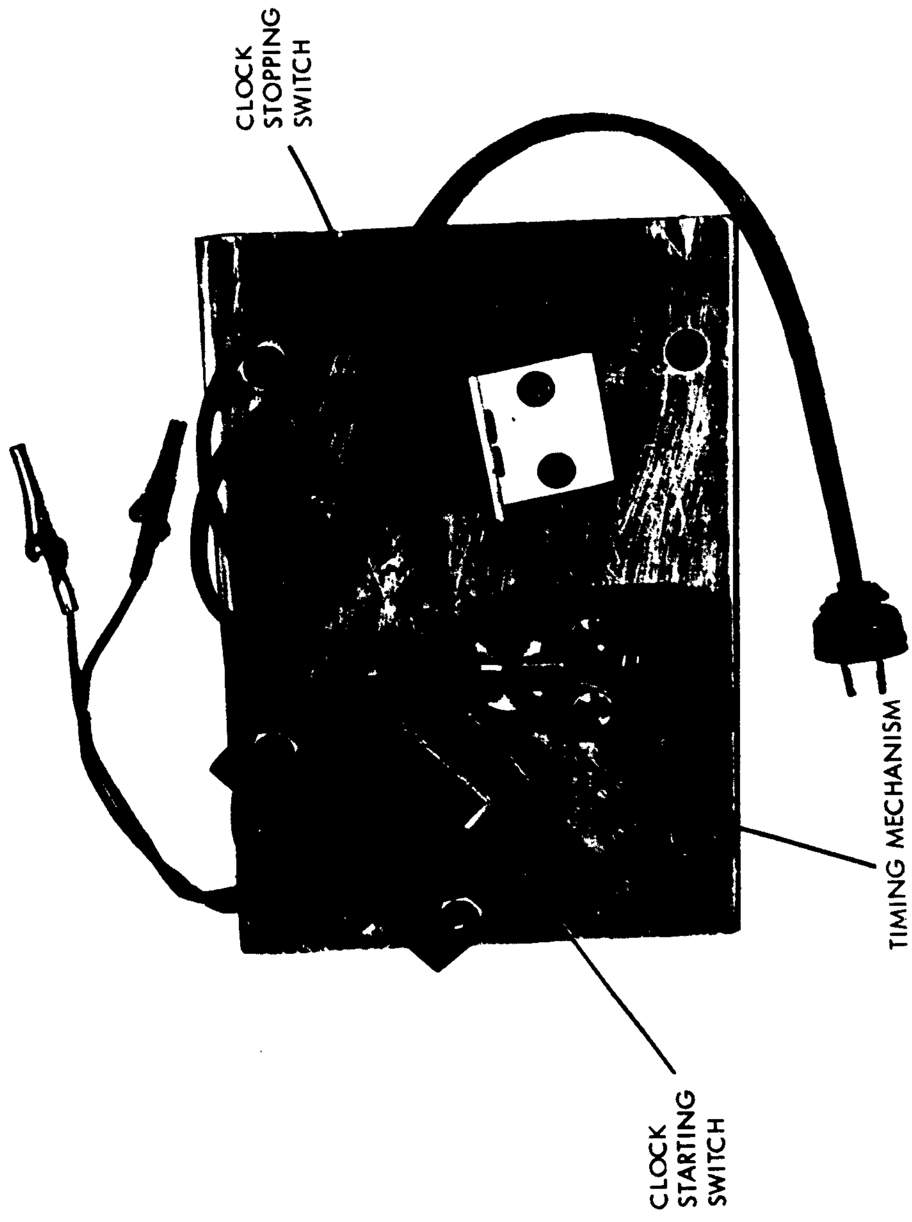


Fig. 8 MECHANISM TIMING FIXTURE

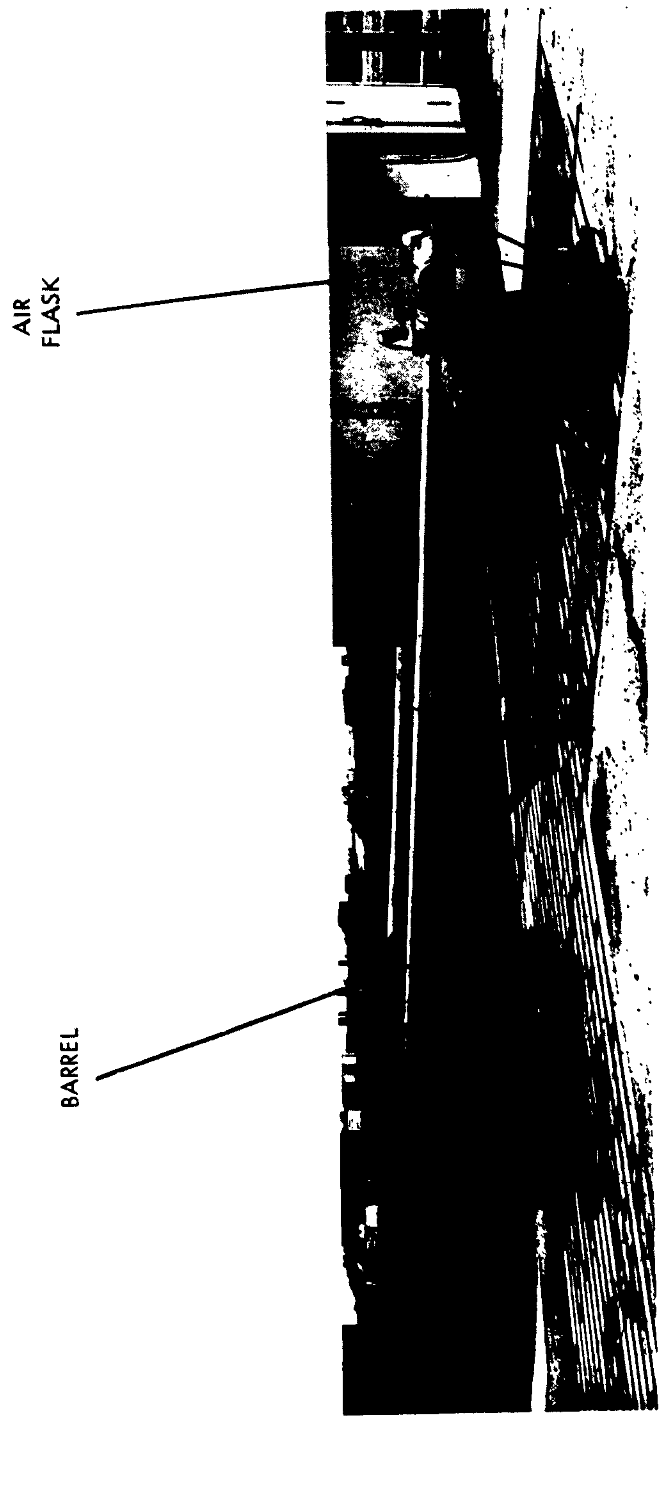


Fig. 9 AIR GUN

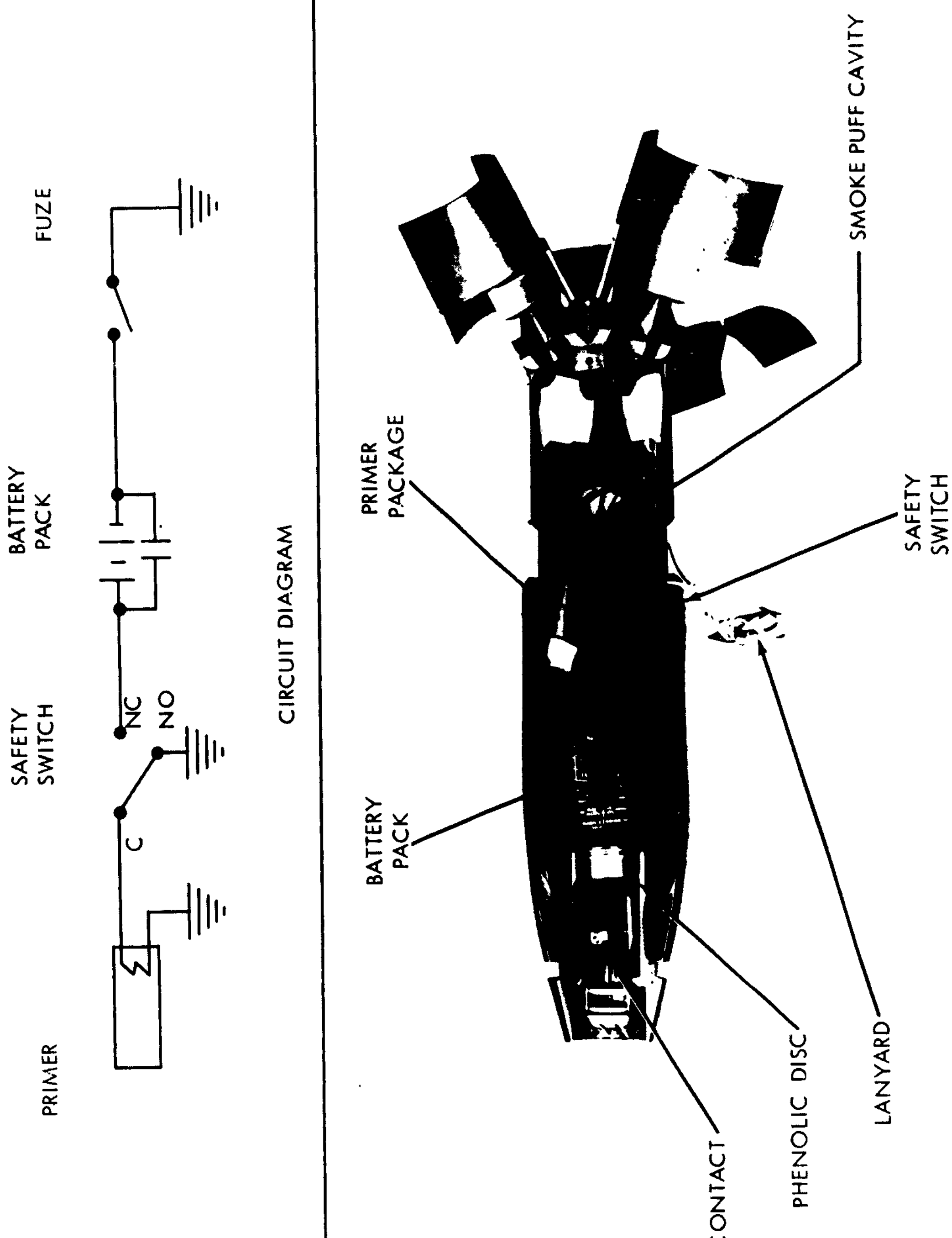


Fig. 10 ARMING TIME MODIFICATION, CUTAWAY VIEW

TEST	NO. SAMPLES	LOT	RESULTS
MIL-STD-304 TEMPERATURE & HUMIDITY	10	G	FAILED
TEMPERATURE CYCLING	10	G	PASSED
MIL-STD-306 SALT SPRAY	10	H	FAILED
MIL-STD-303A TRANSPORTATION VIBRATION	10	G	PASSED
SEQUENTIAL-TEMP CYCLING, TRANS VIB.	5	G	PASSED
SEQUENTIAL-TRANS VIB., TEMP CYCLING	5	G	ONE NOT OPERABLE
AIRCRAFT VIBRATION	10	H	PASSED
STOCKPILE-TO-TARGET	10	G	TWO NOT OPERABLE
MIL-STD-315 DETONATOR SAFETY	30	G	PASSED
FIRING TRAIN RELIABILITY	30	G	PASSED
MIL-STD-300 JOLT	20	G	FAILED
MIL-STD-300 JOLT	10	I	PASSED
MIL-STD-301 JUMBLE	20	G	PASSED
MIL-STD-302 FORTY-FOOT DROP	10	G	PASSED
MIL-STD-358 FIVE-FOOT DROP	10	H	FAILED
LABORATORY TIMING	20	F	OPERABLE AT +160°F, AMB, -65°F
-80°F STORAGE	5	H	2/5 NOT OPERABLE
EXTREME TEMP STORAGE	10	G	PASSED
OPERATION AT TEMP EXTREMES	20	H	1/10 AT -65°F, AND 2/10 AT +160°F DUDS
MINIMUM ARMING VELOCITY	10	H	4/10 NEEDED OVER 200 KTS TO ARM
PACKAGE EVALUATION	20	H	PASSED
PENETRATION	55	E	DUDS AT 70° OBLIQUITY
SENSITIVITY	30	H	2/5 DUDS VS 1/16 STEEL, 200'/SEC, 70° OBL.
MIL-STD-311 ACCIDENTAL RELEASE	30	F	8 ARMED
IMPACT SAFETY (ROTOR ARMED. NO SHROUD OR FIRING PIN ASSEMBLY.)	27	E	AT 160 KTS, WILL FIRE VS CONCRETE AND STEEL.
IMPACT SAFETY (SAFE FUZE)	4	E	PASSED
MIL-STD-307A JETTISON SAFETY	30	F	WEAPON EXPLODED
ARMING TIME	60	H	LONGER THAN EXPECTED
FLY-AROUND	20	F	WITHOUT NOSE FAIRING, 3 ARMED
OPERABILITY VS GROUND	396	F, G, H	41 DUDS

NOTE: LOT E - HAS NO DOUBLE DETENT ASSEMBLY. HAS SMALL TIP ON TOP OF FIRING PIN.
LOT F - HAS DOUBLE DETENT ASSEMBLY. SCREWS CEMENTED WITH GLYPTAL. HAS IMPROVED ASSEMBLY PLATE STAKE. TIP ON FIRING PIN REMOVED.
LOT G - LIKE LOT F, BUT HAS .035 INCH ALUMINUM EXTENSION ON FIRING PIN. ASSEMBLY SCREWS CEMENTED WITH EPON 828.
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LOT I - LIKE LOT H, BUT HAS WASHERS SOLDERED TO UNDER SIDES OF ASSEMBLY SCREW HEADS.

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4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5 AUTHOR(S) (Last name, first name, initial)

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13 ABSTRACT

This report contains the results of the comprehensive technical evaluation to which the fuze was subjected. An introduction briefly outlines the desirable results which were obtained, as well as the problem areas, and describes the various fuze modification which were included in the evaluation. The report contains a description of both the ROCKEYE I weapon and bomblet fuze, and an explanation of their operation. The main body of the report describes the individual tests and gives the results. Another section discusses the results and draws conclusions concerning the merits of the fuze. Illustrations include cutaway views of the fuze, bomblet and weapon, a flow chart of the evaluation program, and special equipment used during the program. (U)

DD FORM 1 JAN 64 1473

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
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Bomb Fuzes						
Free Fall Weapons						
ROCKEYE I						

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There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 64-97)
TECHNICAL EVALUATION OF THE ROCKEYE I BOMBLET FUZE MK 258 MOD 0 (U), by L. J. Shkolnik. 14 May 1964. 18p. illus., tables. BuWeps task RMMO-22 RM 37 73001/212-1/W114-00/03.

CONFIDENTIAL

This report contains the results of the comprehensive technical evaluation to which the fuze was subjected. It contains a description of both the ROCKEYE I weapon and bomblet fuze, and an explanation of their operation. The report describes the individual tests, discusses the results and draws conclusions concerning the merits of the fuze. Illustrations include cutaway views of the fuze, bomblet and weapon, and special equipment used during the program. (U)

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